T08D11 – Acid Base Topic SL Exam

Name KEY

1. Four aqueous solutions, I, II, III and IV, are listed below.

I. 0.100 mol dm^{-3} HCl SA $-\log(.1) = pH\ 1$

II. 0.010 mol dm^{-3} HCl SA $-\log(.01) = pH\ 2$

III. 0.100 mol dm^{-3} NaOH SB $-\log(.1) = pOH\ 1 \rightarrow pH\ 13$

IV. 0.010 mol dm^{-3} NaOH SB $-\log(.01) = pOH\ 2 \rightarrow pH\ 12$

What is the correct order of **increasing** pH of these solutions?

A. I, II, III, IV

(B.) I, II, IV, III $I < II < IV < III$

C. II, I, III, IV

D. II, I, IV, III

2. Which methods will distinguish between equimolar solutions of a strong base and a strong acid?

I. Add magnesium to each solution and look for the formation of gas bubbles.

II. Add aqueous sodium hydroxide to each solution and measure the temperature change.

III. Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.

(A.) I and II only (I) - Acids corrode active metals to form H_2 gas & salt.

B. I and III only (II) - A/B neutralization reactions are exothermic

C. II and III only ~~III~~ - Both A & B conduct electricity as both are electrolytes

D. I, II and III

3. Which **one** of the following species can act as both a Brønsted-Lowry acid and base in aqueous solution?

A. CH_3COOH

B. NO_3^- $H_2PO_4^- + H^+ \longrightarrow H_3PO_4$ (B → cA)

(C.) $H_2PO_4^-$

D. OH^- $H_2PO_4^- \longrightarrow H^+ + HPO_4^{2-}$ (A → cB)

4. An aqueous solution of which of the following reacts with magnesium metal?

A. Ammonia

(B.) Hydrogen chloride ← The only strong Acid (HCl) reacts w/ active metals.

C. Potassium hydroxide

D. Sodium hydrogencarbonate

5. Which is a conjugate acid-base pair in the following reaction?

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

A. HNO_3 and H_2SO_4 not same compound

(B.) HNO_3 and $H_2NO_3^+$ $HNO_3 + H^+ \longrightarrow H_2NO_3^+$ (B → cA)

C. HNO_3 and HSO_4^- not same compound

D. $H_2NO_3^+$ and HSO_4^- not same compound

6. The equation for the reaction between nitric acid and sulfuric acid is shown below.

$$H_2SO_4 + HNO_3 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

Which species are acting as acids in this reaction according to the Brønsted-Lowry theory?

A. H_2SO_4 and HNO_3 A / B

(B.) H_2SO_4 and $H_2NO_3^+$ $H_2SO_4 \longrightarrow H^+ + HSO_4^-$ (A → cB); $HNO_3 + H^+ \longrightarrow H_2NO_3^+$ (B → cA)

C. HNO_3 and $H_2NO_3^+$ B / A

D. $H_2NO_3^+$ and HSO_4^- A / B

7. Which of the following is/are formed when a metal oxide reacts with a dilute acid?

I. A metal salt
II. Water
III. Hydrogen gas

A. I only
B. I and II only
C. II and III only
D. I, II and III

Ex. $MgO + 2HCl \rightarrow MgCl_2 + H_2O$

metal salt + water

8. The pH of a solution is 2. If its pH is increased to 6, how many times greater is the $[H^+]$ of the original solution?

A. 3
B. 4
C. 1000
D. 10 000

2 → 3 → 4 → 5 → 6
$10 \times 10 \times 10 \times 10 = 10{,}000$

$[0.01]$ = pH 2
$[0.000001]$ = pH 6

9. Which equation represents an acid-base reaction according to the Lewis theory **but not** according to the Brønsted-Lowry theory?

A. $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$
B. $Cu^{2+}(aq) + 4NH_3(aq) \rightarrow CU(NH_3)_4^{2+}(aq)$
C. $BaO(s) + H_2O(l) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$
D. $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

10. Lime was added to a sample of soil and the pH changed from 4 to 6. What was the corresponding change in the hydrogen ion concentration?

A. increased by a factor of 2
B. increased by a factor of 100
C. decreased by a factor of 2
D. decreased by a factor of 100

4 → 5 → 6
$10 \times 10 = 100$

11. Which substance can be dissolved in water to give a 0.1 mol dm^{-3} solution with a high pH and a high electrical conductivity?

A. HCl
B. NaCl
C. NH_3
D. NaOH → the only strong base

high pH → must be base
high electrical → must be strong

12. In which reaction is $H_2PO_4^-(aq)$ acting as a Brønsted-Lowry base? → meaning it accepts protons in the form of H^+

A. $H_2PO_4^-(aq) + NH_3(aq) \rightarrow HPO_4^{2-}(aq) + NH_4^+(aq)$
B. $H_2PO_4^-(aq) + OH^-(aq) \rightarrow HPO_4^{2-}(aq) + H_2O(l)$
C. $H_2PO_4^-(aq) + C_2H_5NH_2(aq) \rightarrow HPO_4^{2-}(aq) + C_2H_5NH_3^+(aq)$
D. $H_2PO_4^-(aq) + CH_3COOH(aq) \rightarrow H_3PO_4(aq) + CH_3COO^-(aq)$

$H_2PO_4^- + H^+ \rightarrow H_3PO_4$ (B) CA

13. The pH of solution **X** is 1 and that of **Y** is 2. Which statement is correct about the hydrogen ion concentrations in the two solutions?

A. $[H^+]$ in **X** is half that in **Y**.
B. $[H^+]$ in **X** is twice that in **Y**.
C. $[H^+]$ in **X** is one tenth of that in **Y**.
D. $[H^+]$ in **X** is ten times that in **Y**.

$pH_X = 1 \rightarrow 10^{-1} = 0.10$
$pH_Y = 2 \rightarrow 10^{-2} = 0.01$
} x10 diff.

$10^{-pH} = [H^+]$

14. When the following 1.0 mol dm^{-3} solutions are listed in increasing order of pH (lowest first), what is the correct order?

A. $HNO_3 < H_2CO_3 < NH_3 < Ba(OH)_2$
B. $NH_3 < Ba(OH)_2 < H_2CO_3 < HNO_3$
C. $Ba(OH)_2 < H_2CO_3 < NH_3 < HNO_3$
D. $HNO_3 < H_2CO_3 < Ba(OH)_2 < NH_3$

$Ba(OH)_2$ = strong base (fully)
NH_3 = weak base (partially)
H_2CO_3 = weak acid (partially)
HNO_3 = strong acid (fully)
} based on A/B & dissociation.

15. Which substance, when dissolved in water, to give a 0.1 mol dm^{-3} solution, has the highest pH?

A. HCl
B. NaCl
C. NH_3
D. NaOH

Repeat question #11, oops, FREEBIE! ☺

16. Lime is added to a lake to neutralize the effects of acid rain. The pH value of the lake water rises from 4 to 7. What is the change in concentration of H^+ ions in the lake water?

A. An increase by a factor of 3
B. An increase by a factor of 1000
C. A decrease by a factor of 3
D. A decrease by a factor of 1000

4 → 5 → 6 → 7
$10 \times 10 \times 10 = 1000$

17. Which change in $[H^+]$ causes the biggest increase in pH?

A. A change in $[H^+(aq)]$ from 1×10^{-3} to 1×10^{-2} mol dm^{-3}
B. A change in $[H^+(aq)]$ from 1×10^{-3} to 1×10^{-4} mol dm^{-3}
C. A change in $[H^+(aq)]$ from 1×10^{-4} to 1×10^{-2} mol dm^{-3}
D. A change in $[H^+(aq)]$ from 1×10^{-4} to 1×10^{-6} mol dm^{-3}

$H^+ = 1\times10^{-6}$ mol/L pH = 6
↑
$H^+ = 1\times10^{-4}$ mol/L pH = 4
} increase by 2

18. Which methods can distinguish between solutions of a strong monoprotic acid and a weak monoprotic acid of the same concentration?

I. Add magnesium to each solution and measure the rate of the formation of gas bubbles.
II. Add aqueous sodium hydroxide to each solution and measure the temperature change.
III. Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

I - SA react faster than WA
II - more vigorous (↑ exothermic) rxn w/ SA
III - SA are more dissociated & better electrolytes.

19. Which species are a conjugate pair according to the Brønsted-Lowry theory?

A. CH_3COOH and CH_3CHO
B. NH_3 and BF_3
C. $H_2NO_3^+$ and NO_3^-
D. H_2SO_4 and HSO_4^-

$H_2SO_4 \longrightarrow H^+ + SO_4^{2-}$
A CB

20. Which is **not** a strong acid?

A. Nitric acid → HNO_3
B. Sulfuric acid → H_2SO_4
C. Carbonic acid → H_2CO_3 → weak Acid.
D. Hydrochloric acid → HCl

21. Which is a Brønsted-Lowry acid-base pair?

A. H_2O and O^{2-}

B. CH_3COOH and CH_3COO^- $CH_3COOH \longrightarrow CH_3COO^- + H^+$ (A / CB)

C. NH_4^+ and NH_2^-

D. H_2SO_4 and SO_4^{2-}

22. Which species can act as a Lewis acid?

A. BF_3 was octet deficient + accepted a pair of electrons in a bond.

B. OH^-

C. H_2O

D. NH_3

23. What is the conjugate base of the HSO_4^-(aq) ion?

A. H_2SO_4(aq)

B. SO_4^{2-}(aq) $HSO_4^- \longrightarrow H^+ + SO_4^{2-}$ (A / CB)

C. H_2O(l)

D. H_3O^+(aq)

24. The pH of a solution changes from pH = 1 to pH = 3. What happens to the $[H^+]$ during this pH change?

A. It increases by a factor of 100.

B. It decreases by a factor of 100. $1 \rightarrow 2 \rightarrow 3$ $10 \times 10 = 100$

C. It increases by a factor of 1000.

D. It decreases by a factor of 1000.

25. Which acids are strong?

I. HCl(aq) hydrochloric acid

II. HNO_3(aq) nitric acid } all strong acids

III. H_2SO_4(aq) sulfuric acid

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

26. Solutions of hydrochloric acid (HCl(aq)) and ethanoic acid (CH_3COOH(aq)) of the same concentration reacted completely with 5.0 g of calcium carbonate in separate containers. Which statement is correct?

A. CH_3COOH(aq) reacted slower because it has a lower pH than HCl(aq).

B. A smaller volume of CO_2(g) was produced with CH_3COOH(aq) than with HCl(aq).

C. A greater volume of CO_2(g) was produced with CH_3COOH(aq) than with HCl(aq).

D. The same volume of CO_2(g) was produced with both CH_3COOH(aq) and HCl(aq).

Both monoprotic acids (HCl & CH_3COOH) and therefore has the same # of H^+ ions to neutralize

27. (a) (i) A solution of hydrochloric acid has a concentration of 0.10 mol dm^{-3} and a pH value of 1. The solution is diluted by a factor of 100. Determine the concentration of the acid **and** the pH value in the diluted solution.

0.10 mol/L pH = 1

0.001 mol/L pH = 3

(2)

(ii) Explain why 0.10 mol dm^{-3} ethanoic acid solution and the diluted solution in (a) (i) have similar $[H^+]$ values.

Ethanoic Acid is a weak acid and therefore only partially dissociated, where hydrochloric is a strong acid and fully dissociated. Only 1 molecule in 100 dissociate, so the same as 0.001 M HCl. **(3)**

(b) Suggest **one** method, other than measuring pH, which could be used to distinguish between solutions of a strong acid and a weak acid of the same concentration. State the expected results.

Option 1 - measure electrical conductivity
High Conductivity = strong A, low conductivity = weak A
Option 2 - React w/ Magnesium a other active metal.
Strong Acids have faster reaction
Option 3 - Titration Curve explanation
SA/SB = equiv at pH 7
WA/SB = equiv pH > 7 **(2)**
Option 4 - Temperature change, Neutralization rxns are exothermic. **(Total 7 marks)**

28. Vinegar has a pH of approximately 3 and some detergents have a pH of approximately 8. State and explain which of these has the higher concentration of H^+ and by what factor. **(Total 1 mark)**

Vinegar by a factor of 10^5
× 100,000

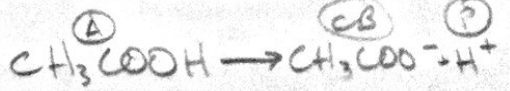
29. The equilibrium reached when ethanoic acid is added to water can be represented by the following equation:

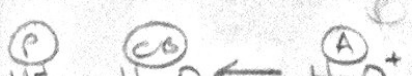
$$CH_3COOH(l) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

Define the terms Brønsted-Lowry acid and Lewis base, and identify two examples of each of these species in the equation. **(Total 4 marks)**

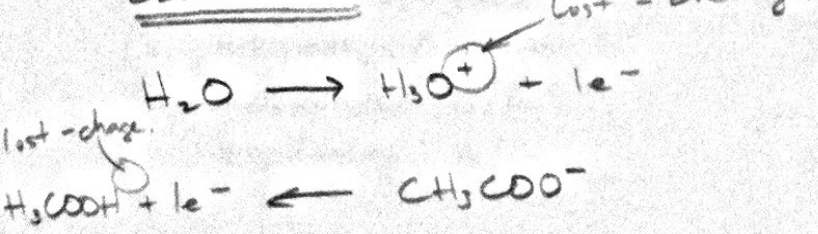
B/L Acid = proton donor
B/L Base = proton acceptor
vs.
Lewis Acid = electron acceptor
Lewis Base = electron donor

B L Acids





Lewis Bases.



30. The pH values of solutions of three organic acids of the same concentration were measured.

acid X	pH = 5
acid Y	pH = 2
acid Z	pH = 3

(i) Identify which solution is the least acidic. **(1)**

Acid X - pH 5 ∴ least acidic

(ii) Deduce how the $[H^+]$ values compare in solutions of acids Y and Z. **(2)**

Greater value in Y, smaller in Z by factor of 10

pH 3 ⇐ $10^{-3} = 0.001$ } $10^{-2} = 0.01$ ⇒ pH 2

(iii) Arrange the solutions of the three acids in decreasing order of electrical conductivity, starting with the greatest conductivity, giving a reason for your choice. **(2)**

(Total 5 marks)

Y > Z > X

most ions = greatest concentration of ions in Y (most acidic)

31. Define the terms *strong acid* and *weak acid*. Using hydrochloric and ethanoic acid as examples, write equations to show the dissociation of each acid in aqueous solution.

Strong Acid – completely dissociated/ionized $HCl \rightarrow H^+ + Cl^-$

Weak Acid – partially dissociated/ionized $CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$

Arrows must be Yields (for strong) and Equilibrium (for weak).

(Total 4 marks)